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<b>(54) Title:</b> CREPING COMPOSITIONS AND PROCESSES  <b>(57) Abstract</b>  Composition comprising at least one water soluble polymer, such as polyamidoamine-epichlorohydrin resin, polyamine-epichlorohydrin resin, polyvinyl alcohol, etc. and at least one stabilizer, such as hypophosphorous acid, phosphorous acid, hypodiphosphoric acid, etc. and salts thereof, suitable as creping adhesive for paper.		

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## Creping Compositions and Processes

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### BACKGROUND OF THE INVENTION

#### Field of the Invention

The present invention relates to stabilizer for creping adhesives and more particularly it relates to a creping composition comprising water soluble  
10 polymer and stabilizer comprising certain acids or salts thereof.

#### Description of the Prior Art

The creping process is commonly practiced in the manufacture of tissue and towel grades of paper. This process involves scraping the dried paper web from a drying cylinder (Yankee dryer) by the use of a creping doctor  
15 blade. The creping action imparts a fine, rippled texture to the sheet and also increases the bulk of the sheet, resulting in improved softness and absorbency. An adhesive formulation is often used to control the adherence of the paper sheet to the Yankee dryer. In this regard, fibrous webs, particularly paper webs, are conventionally subjected to the creping process  
20 in order to give them desirable textural characteristics, such as softness and bulk. The creping process typically involves applying creping adhesive - generally in the form of an aqueous solution, emulsion or dispersion - to a drying surface for the web; preferably, this surface is the surface of a rotating creping cylinder, such as the apparatus known as a Yankee dryer. The web is  
25 then adhered to the indicated surface. It is subsequently dislodged from the surface with a creping device - preferably, a doctor blade. The impact of the web against the creping device ruptures some of the fiber-to-fiber bonds within the web, causing the web to wrinkle or pucker. The creping adhesive solution, emulsion or dispersion can be comprised of one or more adhesive  
30 components, typically water-soluble polymers, and may also contain one or more release agent components as well as other desired additives that may affect the creping process. This is known as the creping adhesive package. This adhesive is exposed to high temperatures (on the order of 100°C) and

high mechanical shear at the creping blade. Given these conditions, one could expect the adhesive formulation to undergo thermooxidative degradation in the presence of atmospheric oxygen. In fact, dark gummy deposits are sometimes observed on the creping blade or Yankee dryer.

5 These deposits are probably thermooxidative degradation products of the creping adhesive formulation and can cause disruptions in the papermaking process. The present invention describes additives for the creping adhesive formulation that significantly reduce the degradation of the creping adhesive formulation under its expected use conditions.

10 Espy & Maslanka, U.S. Patent 5,388,807 and Espy & Giles, Canadian Patent 979,579 disclose polyamidoamine-epichlorohydrin resins (PAE resins) as adhesives in the creping process for producing tissue and towel paper products.

A number of patents disclose the use of hypophosphorous acid and its  
15 salts as an antioxidant in polymeric formulations. These include Papero, U.S. Patent 3,242,134 disclosing use as a stabilizer for polyamides, Yoshitomi, Nagakura and Matsunuma, Japanese Patent 12,997 disclosing use as an antioxidant in the preparation of alkyd resins, Schuler, Swiss Patent 326,175 disclosing use as a light stabilizer for poly(vinyl chloride) and French Patent  
20 1,391,335 (Imperial Chemical Industries Ltd.) disclosing use as a stabilizer in the preparation of polyurethane foams.

The polymers described in the prior art as stabilized by hypophosphorous acid and its salts are all water-insoluble materials. There is no indication given in the prior art that these stabilizers would work in an  
25 aqueous system with a water-soluble polymer.

Chen U.S. 4,883,564 discloses a creping adhesive comprising water-soluble binder (polyvinyl alcohol) and a phosphate salt in order to reduce the hard film build up on the creping surface of the drum dryer.

There is no disclosure in the above references of additives used to  
30 impart thermal stability to the creping adhesive compositions.

There is no mention in the above references of oxidative instability neither of polyamidoamine-epichlorohydrin or polyamine-epichlorohydrin resins nor of the use of hypophosphorous acid and its salts as stabilizers for polyamidoamine-epichlorohydrin or polyamine-epichlorohydrin creping adhesives.

#### SUMMARY OF THE INVENTION

According to the present invention there is provided a composition comprising at least one water soluble polymer selected from the group consisting of polyamidoamine-epichlorohydrin resin, polyamine epichlorohydrin resin, polyacrylamide, polyvinyl alcohol, polyvinylamine, polyethyleneimine, polymethacrylamide, poly(acrylic acid), poly(methacrylic acid), poly(hydroxyethyl acrylate), poly(hydroxyethyl methacrylate), poly(n-vinyl pyrrolidinone), poly(ethylene oxide), hydroxyethyl cellulose, hydroxypropyl cellulose, guar gum, starch, agar, chitosan, alginic acid, carboxymethyl cellulose, highly branched polyamidoamines and silylated polyamidoamines; and at least one stabilizer selected from the group consisting of hypophosphorous acid, phosphorous acid, hypodiphosphoric acid, diphosphorous acid, hypophosphoric acid, pyrophosphorous acid and salts of any of these acids.

Further provided according to the present invention are creping adhesives comprising at least one of the above water soluble polymers and at least one of the above stabilizers.

Provided according to the present invention there are processes of forming creped paper comprising : (a) applying the water soluble polymer and stabilizer of the present invention to a drying surface for fibrous web, (b) pressing a fibrous web against the drying surface to adhere the fibrous web to the drying surface, and (c) dislodging the fibrous web from the drying surface with a creping device to crepe the fibrous web.

#### DETAILED DESCRIPTION OF THE INVENTION

Surprisingly it has been discovered that certain acids, such as phosphorous acid, hypophosphorous acid etc. and their salts are effective

additives in preventing thermal degradation of water soluble polymers, e.g., polyamidoamine-epichlorohydrin and polyamine-epichlorohydrin resins. This type of stabilizer should be useful in the manufacture of tissue papers and paper toweling by providing a more stable creping adhesive coating on the  
5 Yankee dryer.

In the context of the present application the term "polymer" is intended to include homopolymers as well as copolymers.

The stabilizers have been shown to be effective in reducing color formation and charring of water soluble polymers, such as polyamidoamine-  
10 epichlorohydrin and polyamine-epichlorohydrin resins at levels of about 1 to 5%.

The water soluble polymer suitable for the present invention can be selected from the group consisting of polyamidoamine-epichlorohydrin resin, polyamine epichlorohydrin resin, polyvinyl alcohol, polyvinylamine,  
15 polyethyleneimine, acrylamide polymers, polymethacrylamide, poly(acrylic acid), poly(methacrylic acid), poly(hydroxyethyl acrylate), poly(hydroxyethyl methacrylate), poly(n-vinyl pyrrolidinone), poly(ethylene oxide), hydroxyethyl cellulose, hydroxypropyl cellulose, guar gum, starch, agar, chitosan, alginic acid, carboxymethyl cellulose, highly branched polyamidoamines and their  
20 reaction product with epichlorohydrin and silylated polyamidoamines. Preferably the water-soluble polymer is selected from the group consisting of polyamidoamine-epichlorohydrin resin, polyamine-epichlorohydrin resin, highly branched polyamidoamines, silylated polyamidoamines, polyvinyl alcohol, polyvinylamine, polyethyleneimine, acrylamide polymers, poly(N-vinyl  
25 pyrrolidinone), hydroxyethylcellulose and carboxymethylcellulose, and most preferably they are selected from the group consisting of polyamidoamine-epichlorohydrin resin, polyamine-epichlorohydrin resin, highly branched polyamidoamines, silylated polyamidoamines, polyvinyl alcohol, polyvinylamine and polyethyleneimine.

30 The stabilizer is selected from the group consisting of hypophosphorous acid, phosphorous acid, hypodiphosphoric acid,

diphosphorous acid, hypophosphoric acid, pyrophosphorous acid and salts of any of these acids. Preferably the stabilizer is hypophosphorous acid, phosphorous acid, hypodiphosphoric acid, diphosphorous acid, hypophosphoric acid, pyrophosphorous acid, sodium hypophosphite, potassium hypophosphite, lithium hypophosphite, calcium hypophosphite, manganese hypophosphite, magnesium hypophosphite, ammonium hypophosphite, phosphorous acid sodium salt, phosphorous acid potassium salt, phosphorous acid lithium salt, phosphorous acid calcium salt, phosphorous acid magnesium salt, phosphorous acid manganese salt and phosphorous acid ammonium salt and most preferably the acidic compound is hypophosphorous acid, phosphorous acid, sodium hypophosphite, potassium hypophosphite, manganese hypophosphite, ammonium hypophosphite, phosphorous acid sodium salt, phosphorous acid potassium salt and phosphorous acid ammonium salt.

The water soluble polymer can be present in an amount of at least about 25% based upon the weight of composition, and preferably at least about 50%. The water soluble polymer can be present in an amount of up to about 99.99%, preferably up to about 99.75%. The stabilizer can be present in an amount of at least about 0.01%, preferably in an amount of at least about 0.25%. The stabilizer can be present in an amount of up to about 75%, preferably in an amount of up to about 15%. Additional components of the creping package may be the creping release agents disclosed in US Patent 5,660,687 (Allen and Lock) the disclosure of which reference is hereby incorporated by reference in its entirety. Suitable release agents include, for example, aliphatic polyols or oligomers thereof having a number average molecular weight of less than 600, polyalkanolamines, aromatic sulfonamides, pyrrolidone, and mixtures thereof. Specific examples of release agents include, for example, ethylene glycol; propylene glycol; diethylene glycol; glycerol; pyrrolidone; triethanolamine; diethanolamine; polyethylene glycol; dipropylene glycol; Uniplex 108, an aromatic sulfonamide available from Unitex Chemical Corporation, Greenville, NC, USA, and mixtures thereof.

Other components of the creping package may also be the polyalkanoamide tackifiers described WO 99/02486, the disclosure of which is incorporated by reference. In addition, the creping adhesive composition can contain release agents, (typical oil-based formulations) surfactants, dispersants, salts to  
5 adjust the water hardness, acids or bases to adjust the pH of the creping adhesive composition or other useful additives. The use of such adhesive formulations can provide improved product quality and better control of the papermaking process.

The addition of the various phosphorous or hypophosphorous acids or  
10 their salts to formulations of typical polyamidoamine-epichlorohydrin and polyamine-epichlorohydrin creping adhesives has markedly improved thermooxidative stability of these materials. Visual examination of samples that were subjected to high temperatures (150 or 200°C) for 30 minutes showed that the formulations that included 1 to 5% hypophosphite or  
15 phosphorous acid were much lighter in color than the control samples. The control samples acquired a very dark brown charred appearance while the samples with added stabilizer were light to golden yellow in color. The resistance of the stabilized formulations to darkening and charring indicate an improvement in the thermooxidative stability of the creping adhesive  
20 formulation. Thus one would expect increased durability and stability of a creping adhesive composition containing the stabilizers of this invention, which would be expected to result in improved performance of the paper machine and possibly, improved product quality. The compositions of the present invention may also be advantageous in providing improved creping  
25 performance at higher paper machine speeds. This ability to reduce color formation in creping adhesive compositions has also been quantified by a spectrophotometric technique, which is discussed in the Examples.

The composition of the present invention can be used advantageously in the process of creping paper. The creping process according to the present  
30 invention can include the steps of applying the stabilizer and creping adhesive either separately or combined, preferably combined as the creping adhesive



package to a drying surface for fibrous web, providing a fibrous web, pressing the fibrous web against the drying surface to adhere this web to the surface, and dislodging the fibrous web from the drying surface with a creping device to crepe the fibrous web.

5           The various hypophosphorous and phosphorous acids and their salts will also improve the thermooxidative stability of other synthetic, naturally occurring or synthetically-modified natural water-soluble polymers and copolymers such as polyvinyl alcohol, polyvinylamine, polyethyleneimine, polyacrylamide, polymethacrylamide, poly(acrylic acid), poly(methacrylic  
10   acid), poly(hydroxyethyl acrylate), poly(hydroxyethyl methacrylate), poly(n-vinyl pyrrolidinone), poly(ethylene oxide) [poly (ethylene glycol)], hydroxyethyl cellulose (HEC), hydroxypropyl cellulose (HPC), guar gum, starch, agar, chitosan, alginic acid, and carboxymethyl cellulose (CMC). Other useful water-soluble polymers are the highly branched polyamidoamines and their reaction  
15   product with epichlorohydrin disclosed in U.S. Patent 5,786,429, (Allen Case 2) the disclosure of which reference is hereby incorporated by reference in its entirety. These polyamidoamines are preferably characterized by a highly branched structure that lacks the reactive intralinker functionality of the wet strength and creping adhesive resins in the prior art. This highly branched  
20   structure results from reacting a prepolymer of controlled molecular weight – especially a prepolymer of predetermined low molecular weight – with the requisite amount of epichlorohydrin or other intralinking agent.

          Further these intralinked polyamidoamines are preferably nonthermosetting and endcapped intralinked polyamidoamines. Also as a  
25   matter of preference, the intralinked polyamidoamines are free or substantially free of reactive intralinker functionality.

          The intralinked polyamidoamines preferably comprise the reaction product of reactants which include at least one dicarboxylic acid or dicarboxylic acid derivative, at least one polyamine, at least one endcapping  
30   agent, and at least one intralinker. The at least one endcapping agent preferably comprises at least one member selected from the group consisting

of monofunctional amines, monofunctional carboxylic acids, and monofunctional carboxylic acid esters.

Further the intralinked polyamidoamines preferably comprise the reaction product of an endcapped polyamidoamine prepolymer and the at least one intralinker. The endcapped polyamidoamine prepolymer itself preferably comprises the reaction product of the at least one dicarboxylic acid or dicarboxylic acid derivative, the at least one polyamine, and the at least one endcapping agent.

Also as a matter of preference, the endcapped polyamidoamine prepolymer is free or substantially free of amine and carboxyl end groups. Additionally, the endcapped polyamidoamine prepolymer preferably comprises alternating dicarboxylic acid and polyamine residues, and endcaps lacking carboxyl and amine functionality; yet further, the endcaps are preferably amide endcaps.

The endcapped polyamidoamine prepolymer preferably has a  $DP_n$  of about 2 to about 50 – more preferably about 3 to about 25, and still more preferably about 3 to about 10. Also as a matter of preference, the mole ratio of the at least one intralinker, to intralinker reactive amine groups in the endcapped polyamidoamine prepolymer, is between about  $\frac{1}{2} [1/(DP_n - 1)]$  and about  $1/(DP_n - 1)$ . Also useful as the water-soluble polymers are the silyl-linked polyamidoamines disclosed in EP 0 814 108, the disclosure of which reference is hereby incorporated by reference in its entirety.

Preferably, the silyl-linked polyamidoamines are thermosetting. Also as a matter of preference, they are soluble in an aqueous medium.

These silylated polyamidoamines can comprise the reaction product of reactants which comprise at least one dicarboxylic acid or dicarboxylic acid derivative, at least one polyamine, and at least one silylating agent. The reactants further can comprise at least one cationizing agent, and/or at least one endcapping agent.

Particularly, the silylated polyamidoamines can comprise the reaction product of the at least one silylating agent, and a polyamidoamine prepolymer comprising the reaction product of the at least one dicarboxylic acid or dicarboxylic acid derivative and the at least one polyamine; the reactants for  
5 preparing the prepolymer can also include at least one endcapping agent. Preferably, the at least one silylating agent comprises at least one functionality capable of reacting with amine groups in the polyamidoamine prepolymer, and at least one hydrolyzable site.

Also as a matter of preference, the mole ratio of the at least one  
10 silylating agent, to silylating agent reactive amine groups in the polyamidoamine prepolymer, is between about 0.05 and about 2.0. This mole ratio is more preferably between about 0.1 and about 0.75, and between about 0.15 and about 0.5 as a matter of particular preference.

Other possible uses of the stabilized polymers of the present invention  
15 are as improved wet strength agents for paper, in adhesive compositions, as textile fiber treatments, as dispersant, as improved dispersants and/or promotor resins in paper sizing compositions and as components of paper coating formulations.

The scope of the present invention as claimed is not intended to be  
20 limited by the following Examples which are given merely by way of illustration. All parts and percentages are by weight unless otherwise indicated.

#### Examples 1 to 36 and Comparative Examples 1 to 4

In order to test the thermooxidative stability of resin/stabilizer  
25 formulations an accelerated aging test was performed which involved heating samples in a forced air oven and then determining their color. Aqueous solutions of Crepetrol® 80E and Kymene® 557LX polyamidoamine-epichlorohydrin resins available from Hercules Incorporated and Crepetrol® 73 polyamine-epichlorohydrin resin available from Hercules Incorporated were  
30 mixed with candidate stabilizers and were placed in aluminum weighing pans measuring 55 mm diameter x 15 mm high. The total amount of resin and

stabilizer added was 2.00g. The resin formulations were dried in a forced air oven for 30 minutes at either 150°C or 200°C. After removing from the oven the samples were stored in a dessicator until the color determinations were performed. Color determination was done with a Spectrogard Color System spectrophotometer made by BYK-Gardner USA. The yellowness of the samples was determined according to ASTM method D-1925-70, standard test method for yellowness index of plastics.

Yellowness index results for Crepetrol® 80E resin/stabilizer combinations are listed in Table 1. Yellowness index results of Kymene® 557LX and Crepetrol® 73 resins in combination with stabilizers are shown in Table 2. Addition of the hypophosphite and phosphorous acid stabilizers reduced the yellowness of all samples significantly at the concentrations tested (1, 2.5 and 5%) and the reduction in the yellowness index was generally directly proportional to the amount of stabilizer added.

Table 1. Crepetrol® 80E Resin/Stabilizer Formulations

Example	Adhesive	Stabilizer	Temp.(°C)	pH <sup>1</sup>	Yellowness Index <sup>2</sup>
C-1	C-80E	None (control)	200	3.92	116.0
1	C-80E	1.0% Sodium hypophosphite	200	3.92	58.9
2	C-80E	2.5% Sodium hypophosphite	200	3.93	31.6
3	C-80E	5.0% Sodium hypophosphite	200	3.94	17.0
4	C-80E	1.0% Manganese hypophosphite	200	3.90	57.9
5	C-80E	2.5% Manganese hypophosphite	200	3.87	54.6
6	C-80E	5.0% Manganese hypophosphite	200	3.90	37.6
7	C-80E	1.0% Phosphorous acid	200	3.27	71.6
8	C-80E	2.5% Phosphorous acid	200	2.12	29.7
9	C-80E	5.0% Phosphorous acid	200	1.61	27.3
C-2	C-80E	None (control)	150	3.92	113.3
10	C-80E	1.0% Sodium hypophosphite	150	3.92	86.8
11	C-80E	2.5% Sodium hypophosphite	150	3.93	37.6
12	C-80E	5.0% Sodium hypophosphite	150	3.94	26.8
13	C-80E	1.0% Manganese hypophosphite	150	3.90	90.7
14	C-80E	2.5% Manganese hypophosphite	150	3.87	53.3
15	C-80E	5.0% Manganese hypophosphite	150	3.90	36.7
16	C-80E	1.0% Phosphorous acid	150	3.27	79.7
17	C-80E	2.5% Phosphorous acid	150	2.12	49.7
18	C-80E	5.0% Phosphorous acid	150	1.61	28.2

<sup>1</sup>Measured prior to drying.

<sup>2</sup>Determined by ASTM D-1925-70, Standard Test Method for Yellowness Index of Plastics

Table 2. Kymene® 557LX and Crepetrol® 73 Resins with Stabilizers

Example	Adhesive	Stabilizer	Temp.(°C)	pH	Yellowness Index <sup>1</sup>
C-3	K-557LX	None (control)	150	3.48	111.2
19	K-557LX	1.0% Sodium hypophosphite	150	3.56	84.7
20	K-557LX	2.5% Sodium hypophosphite	150	3.57	80.9
21	K-557LX	5.0% Sodium hypophosphite	150	3.59	60.8
22	K-557LX	1.0% Manganese hypophosphite	150	3.49	96.6
23	K-557LX	2.5% Manganese hypophosphite	150	3.53	85.5
24	K-557LX	5.0% Manganese hypophosphite	150	3.55	79.6
25	K-557LX	1.0% Phosphorous acid	150	2.72	86.8
26	K-557LX	2.5% Phosphorous acid	150	1.99	67.0
27	K-557LX	5.0% Phosphorous acid	150	1.42	76.7
C-4	C-73	None (control)	150	4.02	68.7
28	C-73	1.0% Sodium hypophosphite	150	3.90	52.1
29	C-73	2.5% Sodium hypophosphite	150	3.91	22.0
30	C-73	5.0% Sodium hypophosphite	150	3.97	28.3
31	C-73	1.0% Manganese hypophosphite	150	3.92	42.3
32	C-73	2.5% Manganese hypophosphite	150	3.90	24.2
33	C-73	5.0% Manganese hypophosphite	150	3.87	15.6
34	C-73	1.0% Phosphorous acid	150	2.47	51.4
35	C-73	2.5% Phosphorous acid	150	1.35	65.4
36	C-73	5.0% Phosphorous acid	150	0.83	65.0

<sup>1</sup>Determined by ASTM D-1925-70, Standard Test Method for Yellowness Index of Plastics.

What is claimed is:

1. A composition comprising at least one water soluble polymer selected from the group consisting of polyamidoamine-epichlorohydrin resin, polyamine-epichlorohydrin resin, polyvinyl alcohol, polyvinylamine, polyethyleneimine, polyacrylamide, polymethacrylamide, poly(acrylic acid), poly(methacrylic acid), poly(hydroxyethyl acrylate), poly(hydroxyethyl methacrylate), poly(n-vinyl pyrrolidinone), poly(ethylene oxide), hydroxyethyl cellulose, hydroxypropyl cellulose, guar gum, starch, agar, chitosan, alginate acid, carboxymethyl cellulose, highly branched polyamidoamines and their reaction product with epichlorohydrin and silyl-linked polyamidoamines; and at least one stabilizer selected from the group consisting of hypophosphorous acid, phosphorous acid, hypodiphosphoric acid, diphosphorous acid, hypophosphoric acid, pyrophosphorous acid and salts of any of these acids.

2. The composition of claim 1 wherein the water soluble polymer is selected from the group consisting of polyamidoamine-epichlorohydrin resin, polyamine-epichlorohydrin resin, highly branched polyamidoamines, silylated polyamidoamines, polyvinyl alcohol, polyvinylamine, polyethyleneimine, acrylamide polymers, poly(N-vinyl pyrrolidinone), hydroxyethylcellulose and carboxymethylcellulose.

3. The composition of claim 1 wherein the water soluble polymer is selected from the group consisting of polyamidoamine-epichlorohydrin resin, polyamine-epichlorohydrin resin, highly branched polyamidoamines, silylated polyamidoamines, polyvinyl alcohol, polyvinylamine and polyethyleneimine.

4. The composition of claims 1-3 wherein the stabilizer is selected from the group consisting of hypophosphorous acid, phosphorous acid, hypodiphosphoric acid, diphosphorous acid, hypophosphoric acid, pyrophosphorous acid, sodium hypophosphite, potassium hypophosphite,

lithium hypophosphite, calcium hypophosphite, manganese hypophosphite, magnesium hypophosphite, ammonium hypophosphite, phosphorous acid sodium salt, phosphorous acid potassium salt, phosphorous acid lithium salt, phosphorous acid calcium salt, phosphorous acid magnesium salt,  
5 phosphorous acid manganese salt and phosphorous acid ammonium salt.

5. The composition of claim 4 wherein the stabilizer is selected from the group consisting of hypophosphorous acid, phosphorous acid, sodium hypophosphite, potassium hypophosphite, manganese hypophosphite,  
10 ammonium hypophosphite, phosphorous acid sodium salt, phosphorous acid potassium salt and phosphorous acid ammonium salt.

6. The composition of claims 1-5 wherein the water soluble polymer is present in an amount of at least about 25% based upon the weight of the  
15 composition.

7. The composition of claim 6 wherein the water soluble polymer is present in an amount of at least about 50% based upon the weight of the composition.

20 8. The composition of claim 1-7 wherein the water soluble polymer is present in an amount of up to about 99.99% based upon the weight of the composition.

9. The composition of claim 8 wherein the water soluble polymer is present in an amount of up to about 99.75% based upon the weight of the  
25 composition.

10. The composition of claims 1-9 wherein the stabilizer is present in an amount of at least about 0.01% based upon the weight of the composition.

30 11. The composition of claim 10 wherein the stabilizer is present in an amount of at least about 0.25% based upon the weight of the composition.

12. The composition of claim 1-11 wherein the stabilizer is present in an amount of up to about 75% based upon the weight of the composition.

5 13. A creping adhesive comprising the composition of claims 1-12.

14. The creping adhesive comprising the composition of claim 13 further comprising at least one of release agent, surfactant, dispersant, bases and acids and salts other than hypophosphorous acid, phosphorous acid,  
10 hypodiphosphoric acid, diphosphorous acid, hypophosphoric acid, pyrophosphorous acid and salts thereof.

15. A process of forming creped paper comprising:

(a) applying the water soluble polymer and stabilizer of the  
15 composition of claims 1-12 either separately or combined to a drying surface for fibrous web;

(b) pressing a fibrous web against the drying surface to adhere the fibrous web to the drying surface; and

(c) dislodging the fibrous web from the drying surface with a creping  
20 device to crepe the fibrous web.

16. A process of forming creped paper comprising:

(a) applying the creping adhesive of claim 13 to a drying surface for fibrous web;

25 (b) pressing a fibrous web against the drying surface to adhere the fibrous web to the drying surface; and

(c) dislodging the fibrous web from the drying surface with a creping device to crepe the fibrous web.

17. The process of claim 16 wherein the creping adhesive  
30 composition further comprises at least one of release agent surfactant, dispersant, bases and acids and salts other than hypophosphorous acid,



**phosphorous acid, hypodiphosphoric acid, diphosphorous acid,  
hypophosphoric acid, pyrophosphorous acid and salts thereof.**

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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>7</sup>:</b> D21H 21/14, B31F 1/12, D21H 23/56, 17/72 // 17:55, 17:56, 17:28, 17:36, 17:37, 17:31, 17:45, 17:30, 17:26, 17:21, 17:10	<b>A3</b>	<b>(11) International Publication Number:</b> WO 00/09806 <b>(43) International Publication Date:</b> 24 February 2000 (24.02.00)
<b>(21) International Application Number:</b> PCT/US99/18487 <b>(22) International Filing Date:</b> 12 August 1999 (12.08.99)  <b>(30) Priority Data:</b> 09/135,428 17 August 1998 (17.08.98) US  <b>(71) Applicant:</b> HERCULES INCORPORATED [US/US]; Hercules Plaza, 1313 North Market Street, Wilmington, DE 19894-0001 (US).  <b>(72) Inventor:</b> ALLEN, Anthony, John; 1116 Elderon Drive, Arundel, Wilmington, DE 19808 (US).  <b>(74) Agent:</b> KULLER, Mark, D.; Hercules Incorporated, Hercules Plaza, 1313 North Market Street, Wilmington, DE 19894-0001 (US).		<b>(81) Designated States:</b> AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i>  <b>(88) Date of publication of the international search report:</b> 18 May 2000 (18.05.00)
<b>(54) Title:</b> CREPING COMPOSITIONS AND PROCESSES  <b>(57) Abstract</b>  Composition comprising at least one water soluble polymer, such as polyamidoamine-epichlorohydrin resin, polyamine-epichlorohydrin resin, polyvinyl alcohol, etc. and at least one stabilizer, such as hypophosphorous acid, phosphorous acid, hypodiphosphoric acid, etc. and salts thereof, suitable as creping adhesive for paper.		

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# INTERNATIONAL SEARCH REPORT

<b>INTERNATIONAL SEARCH REPORT</b>		Internat / Application No <b>PCT/US 99/18487</b>
<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC 7 D21H21/14 B31F1/12 D21H23/56 D21H17/72 //D21H17:55, D21H17:56, D21H17:28, D21H17:36, D21H17:37, D21H17:31, D21H17:45, D21H17:30, D21H17:26, D21H17:21, D21H17:10 According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) IPC 7 D21H B31F Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practical, search terms used)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 641 818 A (GEORGIA PACIFIC RESINS) 8 March 1995 (1995-03-08) page 2, line 6 page 3, line 11 page 3, line 56 -page 4, line 8 ---	1-17
Y	US 5 382 323 A (FURMAN JR GARY S ET AL) 17 January 1995 (1995-01-17) column 7, line 37 - line 53 ---	1-17
Y	US 5 633 309 A (WALTON-BONGERS CYNTHIA D ET AL) 27 May 1997 (1997-05-27) column 3, line 40 -column 4, line 41 -----	1-17
<div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> Further documents are listed in the continuation of box C.         </div> <div> <input checked="" type="checkbox"/> Patent family members are listed in annex.         </div> </div>		
<div style="display: flex;"> <div style="flex: 1;"> <p>* Special categories of cited documents :</p> <p>*A* document defining the general state of the art which is not considered to be of particular relevance</p> <p>*E* earlier document but published on or after the international filing date</p> <p>*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>*O* document referring to an oral disclosure, use, exhibition or other means</p> <p>*P* document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="flex: 1;"> <p>*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>*Z* document member of the same patent family</p> </div> </div>		
Date of the actual completion of the international search <div style="text-align: center; font-size: 1.2em;">22 November 1999</div>		Date of mailing of the international search report <div style="text-align: center; font-size: 1.2em;">25.02.00</div>
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3018		Authorized officer <div style="text-align: center; font-size: 1.2em;">Naeslund, P</div>

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 99/ 18487

## Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1 (embodiment a), 2 - 17

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

## FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

## 1. Claims: 1 (embodiment a), 2-17

Composition comprising a water soluble polymer which is an epichlorohydrin - comprising polymer and a stabilizer selected from the group consisting of hypophosphorous acid, phosphorous acid, hypodiphosphoric acid, diphosphorous acid, hypophosphoric acid, pyrophosphorous acid and salts of any of these acids; creping adhesive comprising the composition; process of forming creped paper comprising applying the creping adhesive or composition to a drying surface for fibrous web.

## 2. Claims: 1 (embodiment b), 2-17

Composition comprising a water soluble polymer which is a vinyl - comprising polymer and a stabilizer selected from the group consisting of hypophosphorous acid, phosphorous acid, hypodiphosphoric acid, diphosphorous acid, hypophosphoric acid, pyrophosphorous acid and salts of any of these acids; creping adhesive comprising the composition; process of forming creped paper comprising applying the creping adhesive or composition to a drying surface for fibrous web.

## 3. Claims: 1 (embodiment c), 2-17

Composition comprising a water soluble polymer which is a polyethyleneimine and a stabilizer selected from the group consisting of hypophosphorous acid, phosphorous acid, hypodiphosphoric acid, diphosphorous acid, hypophosphoric acid, pyrophosphorous acid and salts of any of these acids; creping adhesive comprising the composition; process of forming creped paper comprising applying the creping adhesive or composition to a drying surface for fibrous web.

## 4. Claims: 1 (embodiment d), 2-17

Composition comprising a water soluble polymer which is an acryl - comprising polymer and a stabilizer selected from the group consisting of hypophosphorous acid, phosphorous acid, hypodiphosphoric acid, diphosphorous acid, hypophosphoric acid, pyrophosphorous acid and salts of any of these acids; creping adhesive comprising the composition; process of forming creped paper comprising applying the creping adhesive or composition to a drying surface for fibrous web.

## FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

## 5. Claims: 1 (embodiment e), 2-17

Composition comprising a water soluble polymer which is a poly(ethylene oxide) and a stabilizer selected from the group consisting of hypophosphorous acid, phosphorous acid, hypodiphosphoric acid, diphosphorous acid, hypophosphoric acid, pyrophosphorous acid and salts of any of these acids; creping adhesive comprising the composition; process of forming creped paper comprising applying the creping adhesive or composition to a drying surface for fibrous web.

## 6. Claims: 1 (embodiment f), 2-17

Composition comprising a water soluble polymer which is a polysaccharide and a stabilizer selected from the group consisting of hypophosphorous acid, phosphorous acid, hypodiphosphoric acid, diphosphorous acid, hypophosphoric acid, pyrophosphorous acid and salts of any of these acids; creping adhesive comprising the composition; process of forming creped paper comprising applying the creping adhesive or composition to a drying surface for fibrous web.

## 7. Claims: 1 (embodiment g), 2-17

Composition comprising a water soluble polymer which is a highly branched or silyl-linked polyamidoamine and a stabilizer selected from the group consisting of hypophosphorous acid, phosphorous acid, hypodiphosphoric acid, diphosphorous acid, hypophosphoric acid, pyrophosphorous acid and salts of any of these acids; creping adhesive comprising the composition; process of forming creped paper comprising applying the creping adhesive or composition to a drying surface for fibrous web.

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Internat. Application No

PCT/US 99/18487

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